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(54) Partition structure for a dynamo-electric machine

(57) A partition structure to be used in a dynamo-electric machine for location between the rotor 5 and stator 4, is composed of a sealing portion 10 adapted to prevent leakage of a fluid and a reinforcing portion 12 formed of a cylindrical coil 11 made of a metal material or a plurality of rings 15 made of a metal material for increasing the thermal and mechanical strength. The reinforcing portion 12 has breaks (13) Fig. 2 which cross lines of magnetic force of the revolving magnetic field at a right angle and which provide electric disconnections on the cylindrical or planar surface defining the reinforcing portion 12, so that the occurrence of an eddy-current resulted from the revolving magnetic field is restricted.

FIG. 1

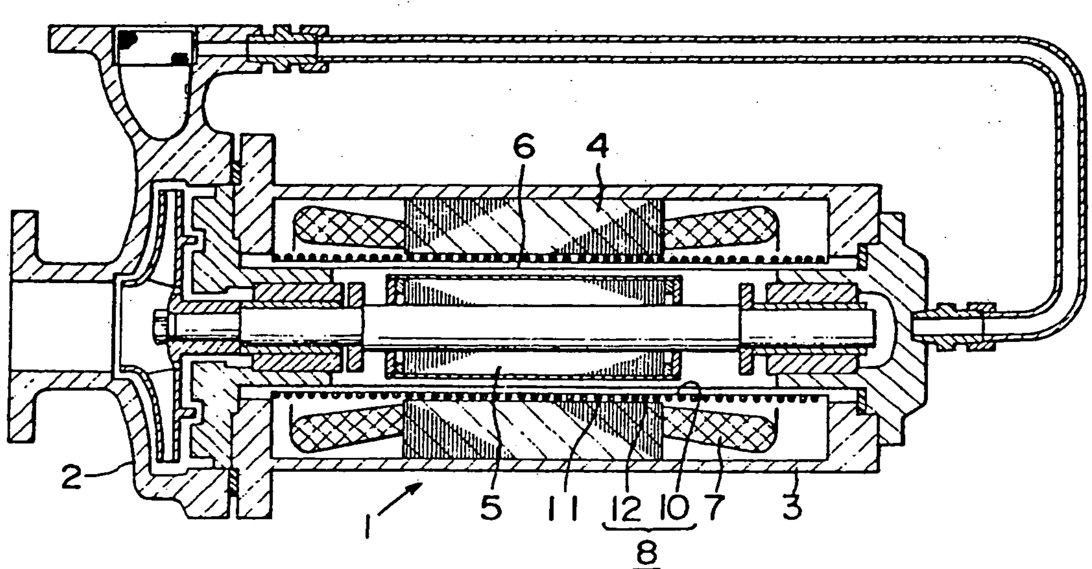

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FIG. 1

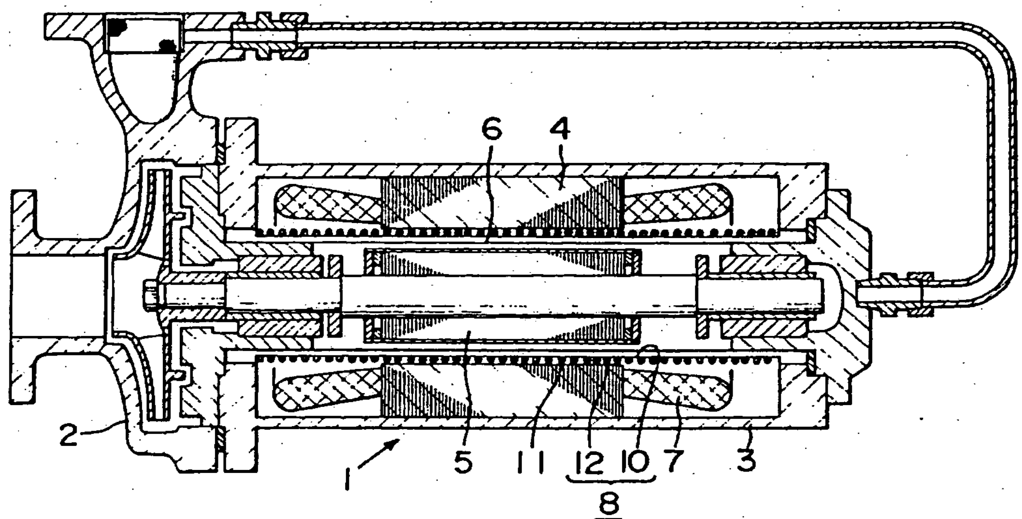


FIG. 2

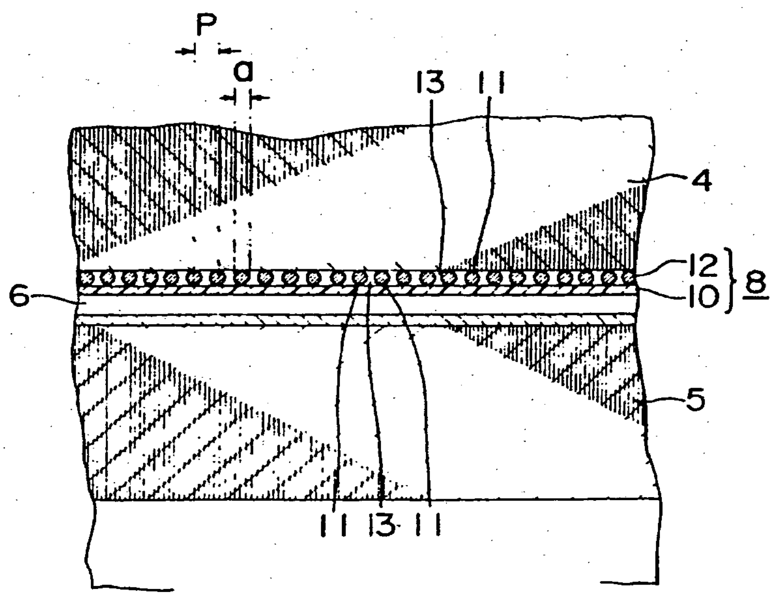


FIG.3

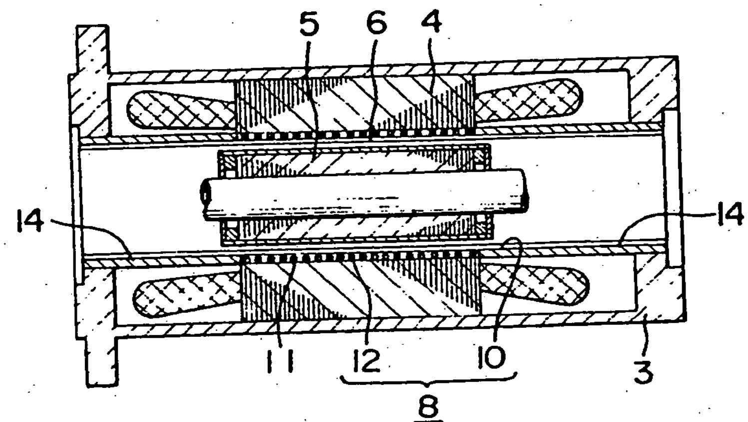


FIG.5

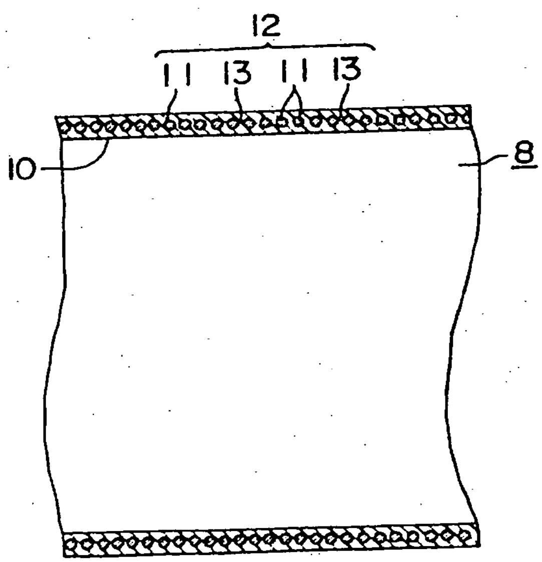
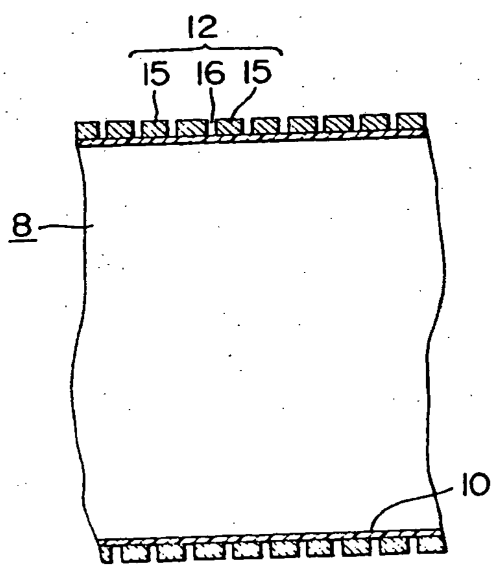


FIG.4



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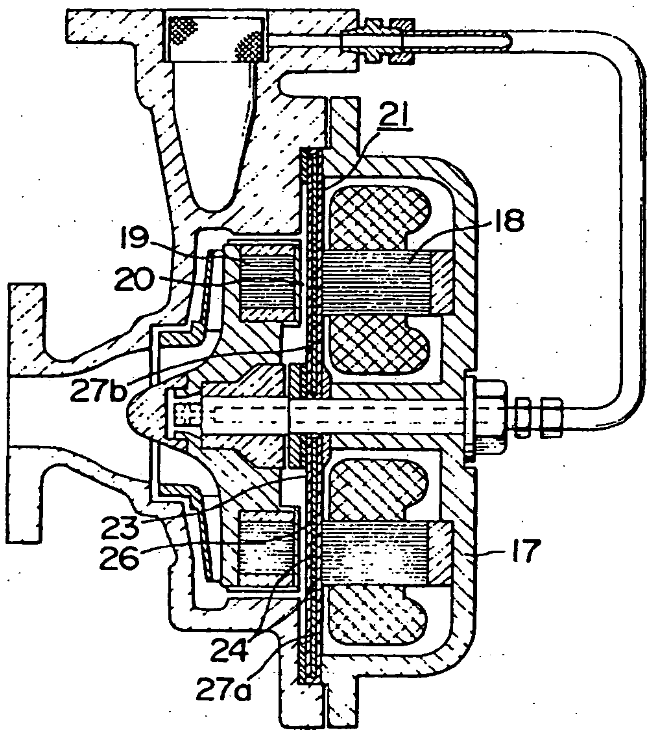

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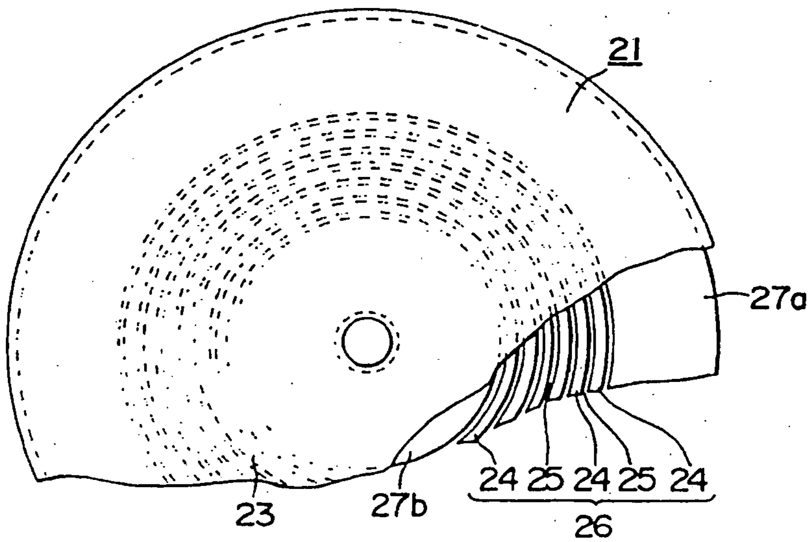

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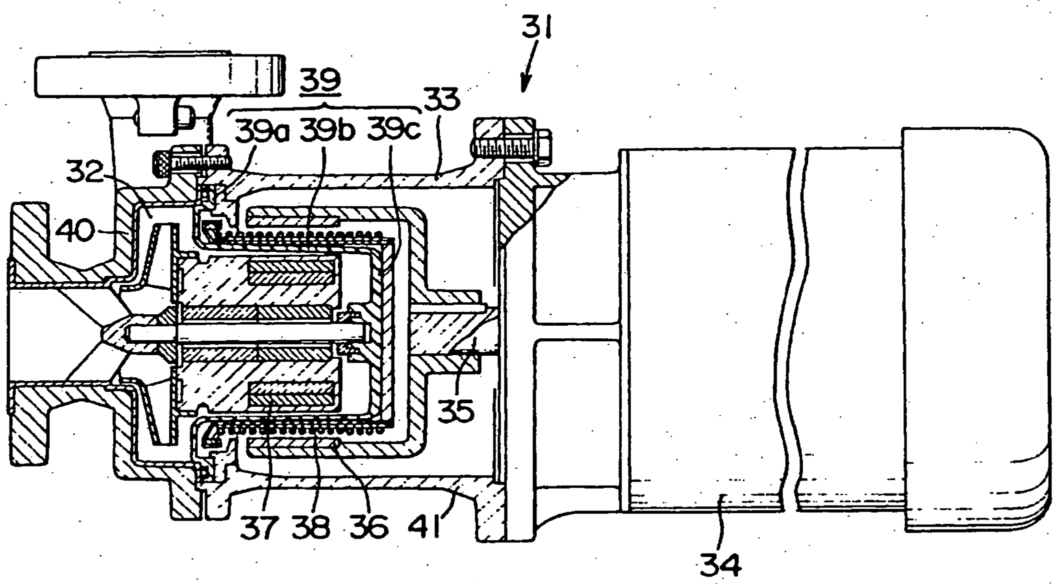

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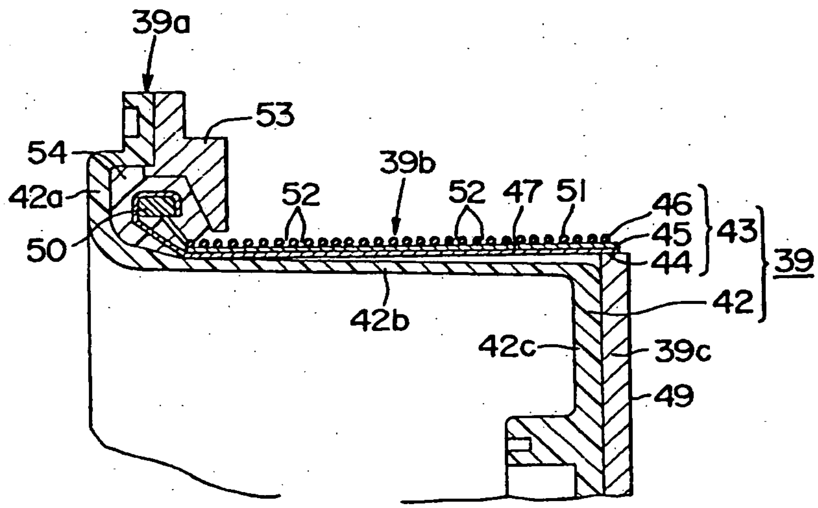
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39c
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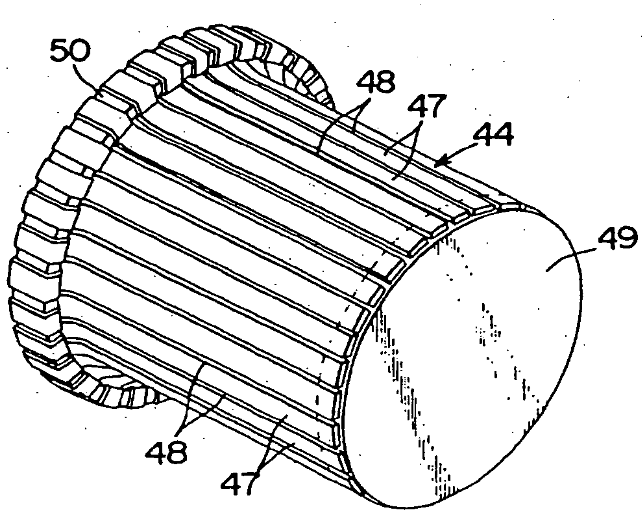
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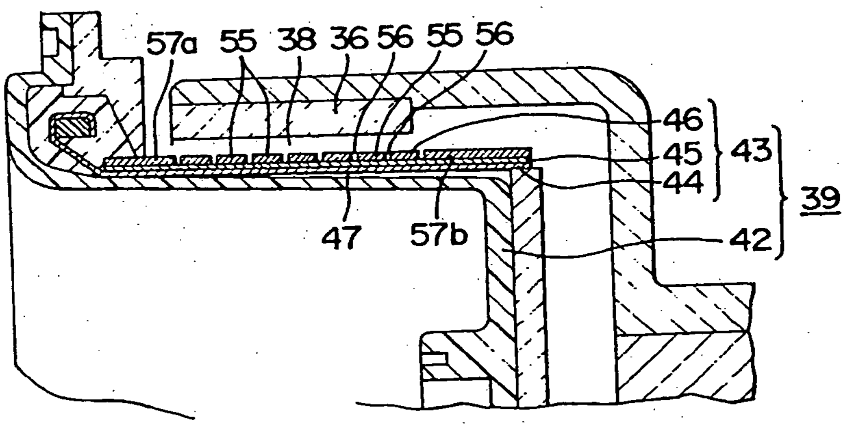
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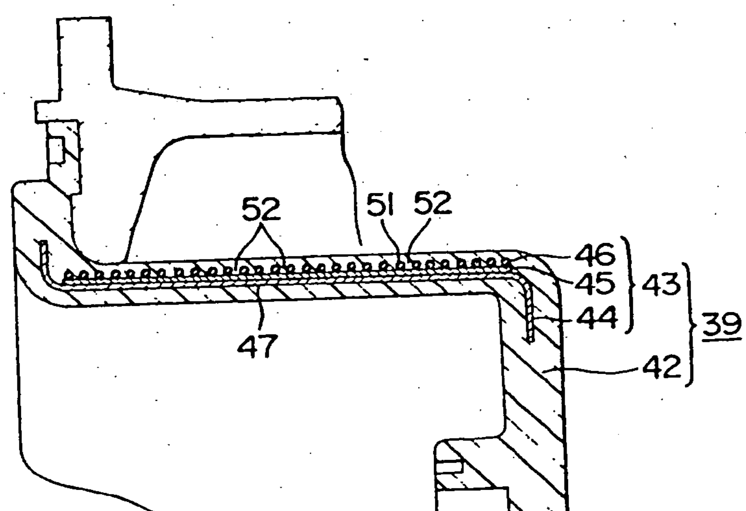
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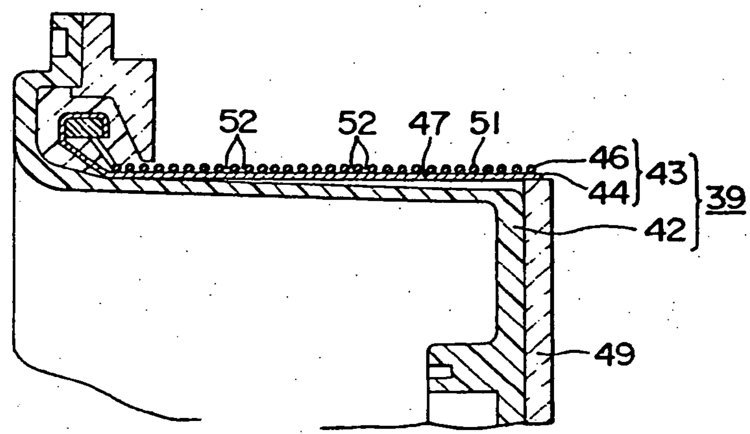
F I G. 13



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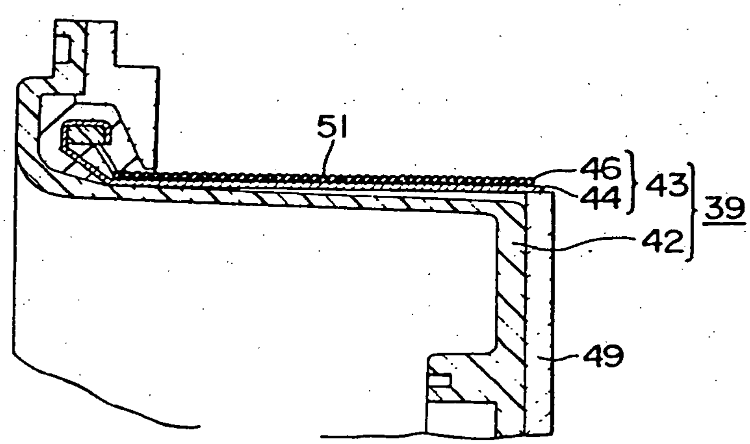


FIG.15

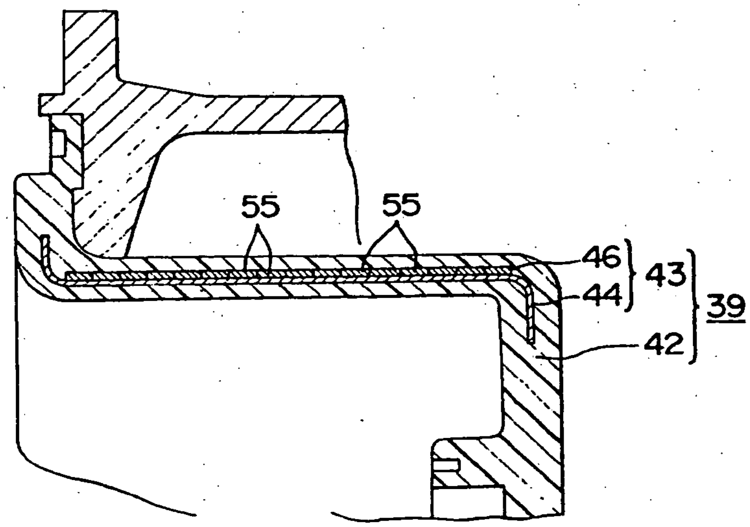


FIG.22

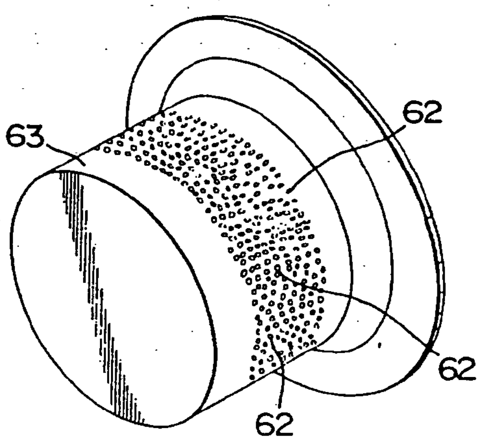


FIG.16

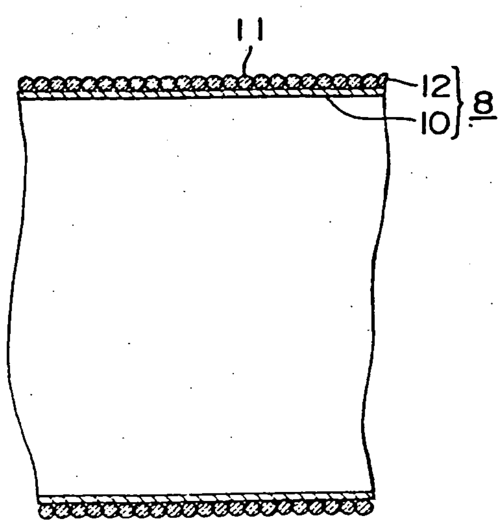


FIG.17

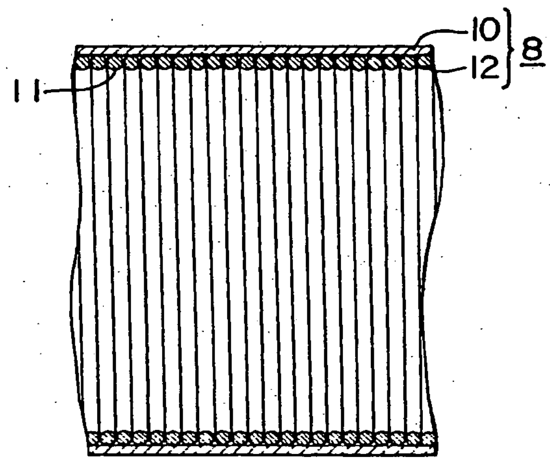
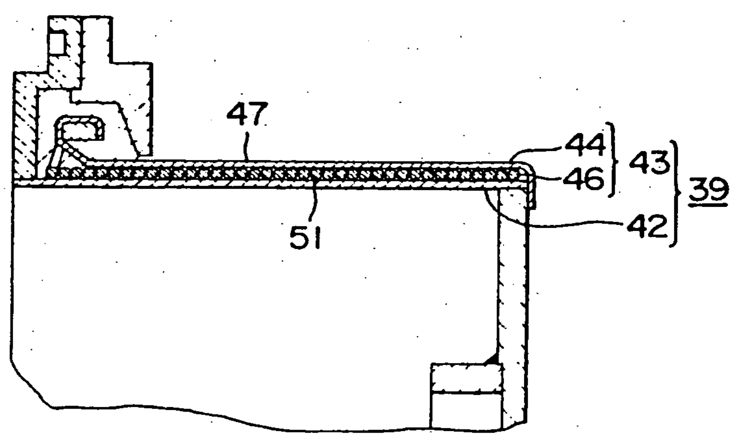


FIG.18



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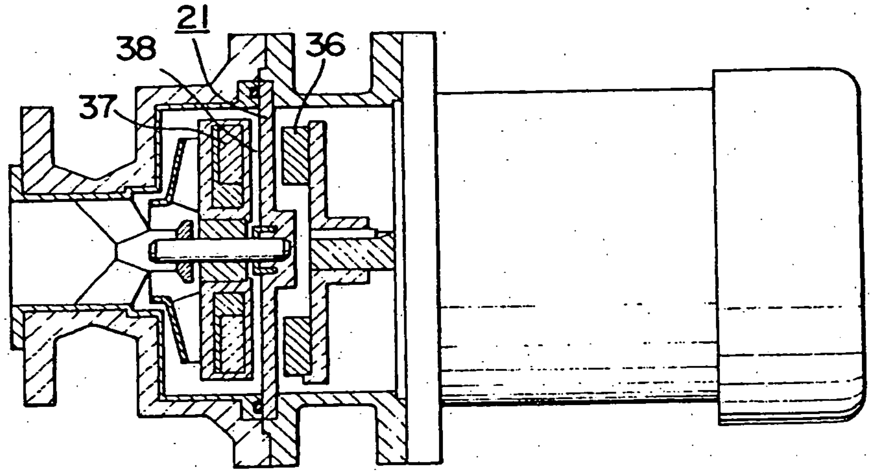

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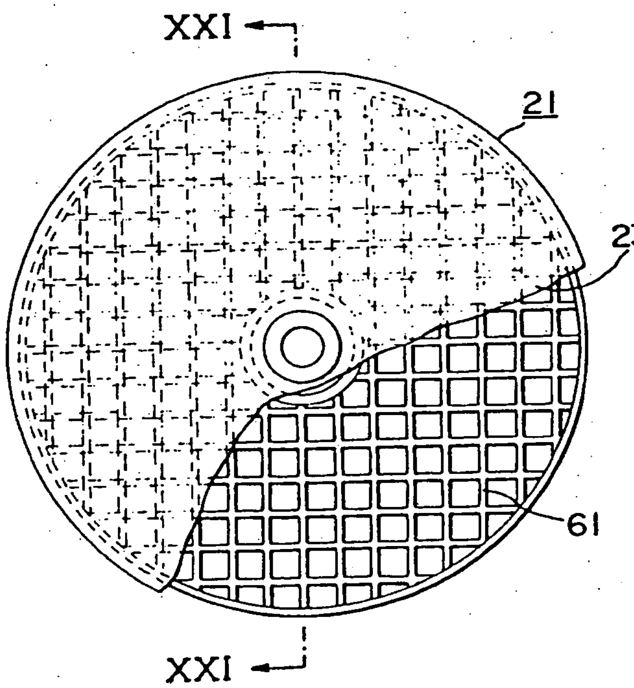

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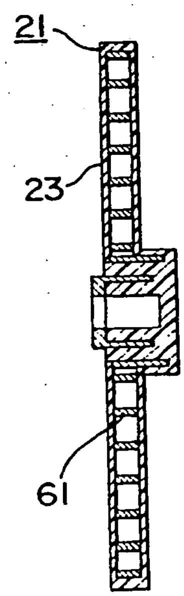
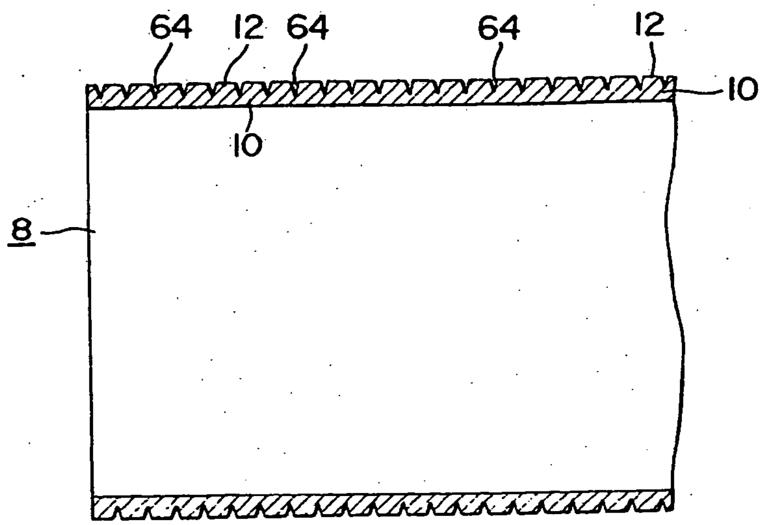


F I G. 23



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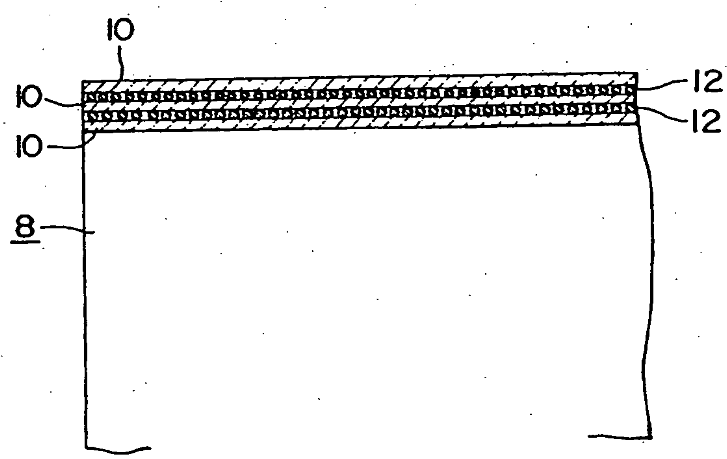

SPECIFICATION

Partition structure for a fluid machine

The present invention relates to a partition structure for a fluid machine,and more particularly to a partition structure disposed in the revolving magnetic field of a fluid machine incorporating a canned motor, magnetic coupling, etc. for interrupting between the interior and the exterior of a fluid system, the partition structure being adapted to greatly reduce an eddy-current loss caused by the revolving magnetic field and improve operation efficiency of the fluid machine.

In general, fluid machines such as a blower, compressor, stirrer, etc. include a shaft sealing part sealed by use of a gland packing, oil seal, mechanical seal, etc. On the other hand, when it is desired to prevent leakage of a fluid being handled, there is employed the so-called glandless fluid machines with no shaft sealing part which incorporate a canned motor or magnetic coupling.

Such a glandless fluid machine incorporating a canned motor or magnetic coupling is so constructed that by passing a polyphase AC current through a stator winding in the canned motor or by rotating a drive magnet in the magnetic coupling, which is disposed inside an enclosed fluid system and directly coupled to a driven section such as an impeller, through a partition structure from outside the fluid system, thereby producing torque. The partition structure serves to interrupt between the inside and the outside of the fluid system, so that leakage of the handled fluid to the stator side of the canned motor or the drive side of the magnet coupling is prevented completely. Accordingly, the above technique is adopted in a fluid machine which uses a flammable,corrosive or toxic fluid or an expensive fluid, i.e., a fluid whose leakage to the outside is undesired.

In this connection, it is preferable for the partition structure of such glandless fluid machine to meet the following five conditions:

(a) Because the partition structure is disposed in the revolving magnetic field of high magnetic flux density, it shall be formed of a non-magnetic substance rather than a magnetic substance which may cause the action of magnetic short-circuiting or magnetic shielding;

(b) Because of disposition in the revolving magnetic field of high magnetic flux density, it shall be formed of a high electric resistance substance with a less eddy-current loss caused by the revolving magnetic field;

(c) It shall have the thermal, mechanical strength endurable against temperature and pressure of the handled fluid;

(d) It shall have the chemical strength (corrosion resistance) against corrosiveness of the handled fluid; and

(e) It shall have leakproof performance to prevent leakage of the handled fluid.

Heretofore, as a partition structure of the foregoing there has been employed a non-magnetic,corrosion-resistive sheet steel made of Austenite stainless steel, Inconel steel, etc. in the form of a cylinder for a radial gap type canned motor because its magnetic gap has a cylindrical shape, or in the form of a disc for an axial gap type canned motor because its magnetic gap has a hollow disc shape.

However, the partition structure formed of the non-magnetic, corrosion-resistive sheet steel completely meets (a), (c) and (e) of the above five conditions, while as for (d) it is poor in corrosion resistance against some of the handled fluids such as hydrochloric acid or dilute sulfic acid and as for (b) it will cause the large amount of an eddy-current loss that accounts for as much as the half of total loss of the motor.

Meanwhile, the magnetic coupling is applied to a fluid machine with generally smaller output as compared with that for the foregoing canned motor, and a resin material is mainly utilized for the partition structure of the former.

But the partition structure formed of only a resin material completely meets (a), (b) and (e) of theabove five conditions and almost completely meets (d) except for solvents, which as for (c) it is poor in the thermal, mechanical strength.

Therefore, it has been usual that, in case of using the handled fluid under high temperature and pressure, or in case of the partition structure with the reduced strength due to an increase in its diameter resulted from an enlarged capacity of the magnetic coupling, the partition structure is formed of only a non-magnetic, corrosion-resistive steel plate similarly to that of the canned motor, or that when use of a resin material is required in point of corrosion resistance, the partition structure is covered with a non-magnetic steel plate having the same shape as the former as a reinforcement for purpose of increasing the strength. In either case, an eddy-current loss as for (b) will be caused by virtue of using the steel plate.

An eddy-current loss caused in the partition structure is resulted from such a mechanism that, because lines of magnetic force of the revolving magnetic field cross the stationary partition structure at a right angle, an induced current flowing in the form of an eddy, i.e., an eddy-current, is caused in the partition structure, and this eddy-current produces a Joule heat loss in

the partition structure.

The value (W_E) of such an eddy-current loss can be calculated using the following equation (1) for the conventional partition structure, i.e., a cylindrical, disk-like or a cup-like partition structure which is continuous all over the the cylindrical or planar surface with no defect and which has a constant thickness:

$$W_E = (\pi/8)D^3 \cdot L \cdot t \cdot B^2 \cdot \omega^2 \cdot \sigma(w) \quad \ldots \quad (1)$$

where

D(m); the diameter of a partition structure in the cylindrical or cup-like partition structure, or the average diameter of a magnetic gap in the disc-like partition structure;

L(m); the axial length of a magnetic gap in the cylindrical or cup-like partition structure, or the difference between the inner and outer radii of a magnetic gap in the disc-like partition structure;

t(m); the thickness of a partition structure;

$B(Wb/m^2)$; the magnetic flux density of a magnetic gap;

ω(rad/sec); the angular speed of the revolving magnetic field; and

$\sigma(\Omega^{-1}/m)$; the specific conductivity of a partition structure.

Accordingly, if the partition structure is formed of only a resin material of high electric resistance, i.e., resin material with the specific conductivity (Ω^{-1}/m) as low as negligible which is generally about10^{-20} time that of the non-magnetic, corrosion-resistive steel plate, an eddy-current loss (W_E) will not be caused substantially and the resultant partition structure is ideal in ths point. However, resin material are poor in the thermal and mechanical strength by nature. For example, the tensile strength at normal temperature of resin materials is inferior in order of more than 10^1 as compared with metal materials such as the above steel plate which undergoes very less variations in the tensile strength depending on temperatures, and the tensile strength will be reduced by half with a rise in temperature of about 100°C even in the resin materials which have relatively good heat resistance. It is thus inevitable to employ a non-magnetic,corrosion-resistive steel plate for the partition structure in case it requires the sufficient thermal and mechanical resistance.

In that case, if the above steel plate will arise no problem in point of corrosion, the steel plate can be used solely and directly to fabricate the partition structure, As an alternative, if a resin material is yet suitable in point of corrosion, the steel plate can be covered on the partition structure made of resin material as a reinforcement.

In either application, however, since an eddy-current is caused in the used steel plate in accordance with the foregoing equation (1), there occurs a substantial loss corresponding to 10 to 20% of the motor output of a canned motor or the transmision power of a magnetic coupling, so that operation efficiency of the fluid machine is lowered. As a result,the canned motor or the magnetic coupling and hence the drive section thereof such as a drive motor are enlarged in size, thereby resulting in disadvantages of the expensive price and the increased operation cost.

The present invention has been accomplished with a view of improving the disadvantages as stated above. It is an object of the present invention to achieve the above improvement in a partition structure for a canned motor or magnetic coupling used in fluid machines, taking into account the fact that the large amount of eddy-current loss was caused from the reason that a metal material such as a non-magnetic,corrosion-resistive steel plate used solely or as a reinforcement for a resin material depending of the need of thermal and mechanical strength was conventionally formed to be continuous all over the cylindrical or planar surface with no defect, the surface crossing lines of magnetic force of the revolving magnetic field, and to have a constant thickness.

Another object of the present invention is to provide a partition structure which comprises a sealing portion for preventing leakage of a fluid and a reinforcing portion made of metal material for increasing the thermal, mechanical strength, the reinforcing portion being formed to restrict occurrence of an eddy-current therein, thus providing the superior thermal, mechanical strength to the partition structure formed of only non-metal material such as a resin material, and also providing the greatly reduced eddy-current loss and the improved operation efficiency of the fluid machine as compared with the conventional partition structure formed of the above metal material continuous with no defect and constant in a thickness solely or as a reinforcement for the non-metal materials such as a resin material.

Other objects and features ofthe present invention will become apparent from the following description in conjunction with the drawings.

Figure 1 is a longitudinal sectional view of a canned motor pump using a radial air-gap type canned motor for showing one embodiment of the present invention;

Figure 2 is an enlarged sectional view of a partition structure section of the motor;

Figure 3 is a longitudinal sectional view of a motor section of a canned motor pump using a radial air-gap type canned motor for showing another embodiment of the present invention;

Figure 4 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention;

Figure 5 is an enlarged sectional view of a partition structure section showing still another embodiment of the present invention;

Figure 6 is a longitudinal sectional view of a canned motor pump using an axial gap type canned motor for showing the present invention;

Figure 7 is a front view of a partition structure section of the motor in Fig. 6 with a part thereof cut away;

Figure 8 is a longitudinal sectional view of a magnetic coupling pump showing another embodiment of the present invention;

Figure 9 is an enlarged sectional view of a part of a partition structure section in Fig. 8;

Figure 10 is a perspective view of a reinforcing portion of the partition structure section in Fig. 8;

Figure 11 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention;

Figure 12 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention;

Figure 13 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention;

Figure 14 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention;

Figure 15 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention;

Figure 16 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention;

Figure 17 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention;

Figure 18 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention;

Figure 19 is a longitudinal sectional view of a magnet coupling pump showing another embodiment of the present invention;

Figure 20 is a front view of a partition structure section in Fig. 19 with part thereof cut away;

Figure 21 is a sectional view taken along the line of XXI–XXI of the partition structure section in Fig. 20;

Figure 22 is a perspective view of a partition structure section showing another embodiment of the present invention;

Figure 23 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention; and

Figure 24 is an enlarged sectional view of a partition structure section showing another embodiment of the present invention.

Herein preferred embodiments of the present invention will be described with reference to the drawings.

Referring first to Figs. 1 and 2 there is shown an embodiment in which the present invention is applied to a canned motor pump using a radial gap type canned motor, reference numeral (1) designates a canned motor pump which comprises a centrifugal pump (2) and a radial air-gap type canned motor (3) liquid-tightly and integrally connected to the former.

In a magnetic air-gap (6) between a stator (4) of the canned motor (3) and a rotor (5) disposed opposite to the stator (4) is produced a revolving magnetic field with a polyphase AC current passing through a stator winding (7) of the stator (4). A cylindrical partition structure (8) is disposed in that revolving magnetic field, i.e., in the magnetic air-gap (6), to be close contact with the surface of the stator (4) opposite to the magnetic air-gap, both end edges of the cylindrical partition structure (8) being liquid-tightly fixed to a frame of the canned motor (3).

The cylindrical partition structure (8) is composed of a cylindrical sealing portion (10) made of a resin material and effective to prevent leakage of a fluid handled by the pump, and a reinforcing portion (12) formed of a cylindrical coil (11) comprising a wire rod, which is made of an Austenite stainless steel as non-magnetic steel and wound round the outer periphery of the sealing portion (10), and effective to increase the thermal, mechanical strength. A winding pitch P of the cylindrical coil (11) in the reinforcing portion (12) is selected to be larger than a diameter *a* of the steel wire rod so that the adjacent wire rods of the coil will not come into contact with each other. In other words, between the adjacent steel wire rods there is formed a spacing (13) in the distance of (p – a), which serves as a defect in the reinforcing portion (12).

According to this embodiment, since the cylindrical partition structure (8) is composed of the cylindrical sealing portion (10) made of a resin material superior in the chemical strength and the cylindrical reinforcing portion (12) formed of the cylindrical coil (11) comprising a steel wire rod superior in the thermal, mechanical strength which is wound round the sealing portion (10),

it has the same chemical strength against temperature and pressure of the fluid handled by the pump as compared with the cylindrical partition structure which is formed of only a resin material having a thickness equal to the total thickness of both sealing portion (10) and reinforcing portion (12) and, on the other hand, it has the superior chemical strength and the very largely reduced eddy-current loss as compared with the conventional cylindrical partition structure formed of metal material such as a non-magnetic, corrosion-resistive steel plate solely or as a reinforcement.

Stated differently, the sealing portion (10) will not cause substantially an eddy-current loss because it is made of a resin material, and the reinforcing portion (12) has very high electric resistance against an eddy-current and renders the insulated state in the axial direction because it is formed into a cylindrical shape with the spacing (13) of (p – a) between the adjacent wire rods of the cylindrical coil (11) to avoid contact of one with the other. In total, the eddy-current loss is extremely restrained to a substantially undetectable level and hence can be ignored completely in practical use.

In this connection, since the revolving magnetic field crosses the cylindrical partition structure (8) perpendicularly only at the magnetic gap (6) in the foregoing embodiment, the reinforcing portion (12) comprising the cylindrical coil (11) may be provided only at the section of the magnetic gap (6) and metal-made rings (14)(14) may be inserted on both sides of the reinforcing portion to be close contact therewith for increasing thethermal, mechanical strength, as shown in Fig. 3.

Further, the steel wire rod formed into a coil may have any arbitrary sectional shape such as a circular, square, or flattened rectangular shape, and it can be made of any metal material which is applicable as a reinforcement. For example, an iron wire made of paramagnetic substance produces the action of magnetic short-circuiting or magnetic shielding as for the above mentioned item (a), but an influence of which is very small in comparison with that of an eddy-current loss as for the item (b), while it can offer the effect of increasing motor performance to some degree because the magnetic gap (6) is substantially decreased. Thus, the material of the steel wire rod is not limited to such a non-magnetic steel as used in theforegoing embodiment.

In place of the cylindrical coil (11) comprising a steel wire rod, the reinforcing portion (12) may be consisted of a plurality of metal-made rings (15) which are arranged in the axial direction in a manner that the adjacent rings will come into contact with each other while leaving a spacing (16) therebetween as a defect, as shown in Fig. 4. With this arrangement there can be also attained the similar effect.

In the embodiments shown in Figs. 1 to 4, however,since the reinforcing portion (12) is formed round the outer periphery of the resin-made sealing portion (10) to constitute the cylindrical partition structure (8), the thermal, mechanical strength thereof is sufficient against the inner pressure imposed from the fluid handled by the pump but very poor against the outer pressure.

From this reason, in case that the pressure of the fluid handled by the pump is in a vacuum system under less than atmospheric pressure,or in case that the canned motor is required for its anti-explosion construction to endure not only the inner pressure imposed from the pump-handled fluid,but also the outer pressure produced by an anti-explosion test to be conducted within the stator (4), the cylindrical sealing portion (8) may be resin-molded integrally with the cylindircal coil (11) or the plural rings (15) being as a core material at the time of resin-molding thereof, i.e., the cylindrical partition structure (8) may be constructed with the reinforcing portion (12) being enclosed in the sealing portion (10), as shown in Fig. 5 by way of an example. The resultant partition structure (8) is superior in the thermal, mechanical strength against the inner pressure as well as the outer pressure, the thermal, mechanical strength being increased, though to some degree, because each spacing (13) or (16) in the reinforcing portion (12) is now filled with the resin material, and there can be also obtained such an advantage that the outer peripheral surface of the partition structure (8) becomes flush entirely and this facilitates to insert the structure (8) onto the stator (4) in a close contact relation.

Figs. 6 and 7 show an embodiment wherein the reinforcing portion (12) of the cylindrical partition structure (8) constructed as shown in Fig. 5 is applied to a canned motor pump incorporating an axial air-gap type canned motor. More specifically, since a magnetic air-gap (20) between a stator (18) and a rotor (19) has a hollow disc-like shape in an axial air-gap type canned motor (17), a disc-like partition structure (21) is disposed in the magnetic air-gap (20) to be fixedly close contact with the surface of the stator (18) opposite to the magnetic air-gap, and it is so constructed that a disc-like sealing portion (23) made of resin material encloses therein a reinforcing portion (26) in which a group of plural metal-made rings (24) having a diameter gradually increasing in the radial direction are concentrically arranged in the magnetic air-gap (20) with a spacing (25) as a defect between the adjacent rings to avoid contact of one with the other, and metal-made discs (27a)(27b) for increasing the thermal, mechanical strength on both outer and inner sides of the reinforcing portion (26) in the radial direction. The reinforcing portion (26) has very high radial electric resistance against an eddy-current and the resultant

eddy-current can be ignored from the standpoint of practical use.

Next, Figs. 8 to 10 show an embodiment wherein the present invention is applied to a magnetic coupling pump incorporating a radial air-gap type magnetic coupling. Reference numeral (31) designates a magnetic coupling pump which comprises a centrifugal pump (32), a magnetic coupling (33) and a motor (34), these components being connected integrally.

In a magnetic air-gap (38) between a drive side magnet (36) of the magnetic coupling (33) directly coupled to a rotary shaft (35) of the motor (34) and a driven side magnet (37) disposed opposite to the drive side magnet (36) is produced the revolving magnetic filled due to rotation of both magnets (36)(37). A cup-like partition structure (39) is liquid-tightly fixed in that revolving magnetic field, i.e., in the magnetic air-gap (38), with its flanged part (39a) being held between a casing (40) of the pump (32) and a frame (41) of the magnetic coupling (33), so that its cylindrical part (39b) may be disposed in no contact relation with both magnets (36)(37).

The cup-like partition structure (39) comprises a cup-like sealing portion (42) made of a resin material for preventing leakage of a fluid handled by the pump, and a reinforcing portion (43) coated on the outer periphery of the sealing portion. The reinforcing portion (43) further comprises a first reinforcing portion (44) for increasing the thermal, mechanical strength in the axial direction, and a second reinforcing portion (46) coated over the first reinforcing portion (44) through an insulating layer (45) for increasing the thermal, mechanical strength in the radial direction.

The first reinforcing portion (44) is constructed as follows. A plurality of bar-like reinforcing pieces (47) made of non-magnetic steels and having a rectangular section are concentrically annularly arranged over the outer peripheral surface of the cylindrical part (42b) of the sealing portion (42) parallel to one another in the axial direction with a spacing (48) between every adjacent pieces. Each of the plural reinforcing pieces (47) has one end welded to an end plate (49) made of a non-magnetic steel disposed adjacent to a bottom part (42c) of the sealing portion (42), and the other end which is bent outward at the flanged part (42a) of the sealing portion (42) and which is locked onto a resin-made ring (50) in no contact relation with another piece.

Further,the outer periphery of the first reinforcing portion (44) is provided with an insulating tape or film wound therearound or undergoes the varnish processing so as to form the insulating layer (45). Over the insulating layer (45) there is circumscribed a cylindrical coil (51) made of a non-magnetic steel with a spacing (52) between every adjacent wires to avoid contact of one with the other, the cylindrical coil (51) having one end welded to the end plate (49) and the other end locked onto the ring (50). The second reinforcing portion (46) is thus constructed.

Meanwhile, a metal-made flange reinforcement (53) is fitted over the flanged part (42a) of the sealing portion (42) and a thermosetting resin filler (54) is filled in a space defined by the reinforcement (53) and the flanged part (42a), thereby rigidly securing the ring (50), the plurality of reinforcing pieces (47) locked on to the ring (50) and the cylindrical coil (51).

In the above, each spacing (48) in the first reinforcing portion (44), each spacing (52) in the second reinforcing portion (46) as well as the insulating layer (45) disposed between the first and second reinforcing portions (44)(46) all serve as defects in the entire reinforcing portion (43).

According to this embodiment, the first reinforcing portion (44) comprises the plurality of bar-like reinforcing pieces (47) which are annularly arranged parallel to one another in the axial direction and each of which has both ends fixed to the flanged part (39a) and the bottom part (39c) of the partition structure (39), respectively, so that it receives an axial pressing force acting upon the bottom part (42c) of the sealing portion (42) with the pressure imposed from the pump-handled fluid, i.e., it bears an axial tensile force acting upon the sealing portion (42). On the other hand, the second reinforcing portion (46) comprises the wire rod which is wound into a coil shape and has both ends fixed to the flanged part (39a) and the bottom part (39c) of the partition structure (39), respectively, so that it receives a radial pressing force acting upon the cylindrical part (42b) of the sealing portion (42) with the pressure imposed from the pump-handled fluid, i.e., it bears a circumferential tensile force acting upon the sealing portion (42)..

Accordingly, the partition structure (39) has the same chemical strength and the greatly improved thermal, mechanical strength against temperature and pressure of the pump-handled fluid as compared with those of the partition structure formed of only a resin material having an equal total thickness.

Further, the first and second reinforcing portions (44)(46) are insulated from each other in the radial direction through the insulating layer (45) except for the both end parts thereof, the first reinforcing portion (44) has very high electric resistance against an eddy-current and renders the insulated state in the circumferential direction because it comprises the plurality of bar-like reinforcing pieces (47) which are arranged parallel to one another in the axial direction with the spacing (48) between every adjacent pieces to avoid contact of one with the other, and further the second reinforcing portion (46) has very high electric resistance against an eddy-current and renders the insulated state in the axial direction because it comprises the cylindrical coil (51)

which is wound with the spacing (52) between every adjacent wires to avoid contact of one with the other, whereby occurrence of an eddy-current is extremely restrained in the entire reinforcing portion (43). As a result, the amount of eddy-current loss caused therein is very largely reduced as compared with the conventional cup-like partition structure using a non-magnetic steel solely or as a reinforcement for the resin material, and it can be ignored completely in practical use.

Incidentally, also in this embodiment the steel wire rod of the cylindrical coil (51) and the individual reinforcing pieces (47) may have any arbitrary sectional shape and can be formed of any metal material which is applicable as a reinforcement.

As an alternative, the second reinforcing portion (46) may be so constructed that, as shown in Fig. 11, a plurality of metal-made rings (55) are axially arranged with a spacing (56) as a defect between every adjacent rings to avoid contact of one with the other. With this arrangement there can be also attained the similar effect.

Further, since the revolving magnet field crosses the cup-like partition structure (39) only at the magnetic air-gap (38), the second reinforcing portion (46) may be provided only at the section of the magnetic air-gap (38) and metal-made rings (57a)(57b) may be disposed on both sides thereof for increasing the thermal, mechanical strength, as shown in Fig. 11.

Moreover, as shown in Fig. 12, if the cup-like partition structure (39) is so constructed that the cup-like sealing portion (42) is resin-molded integrally with the reinforcing portion (43) being as a core material to enclose the same therein at the time of resin-molding the sealing portion, there can be obtained the cup-like partition structure (39) which hasthe thermal, mechanical strength increased, though to some degree, because the resin material is filled in the spacings (48)(52) of the reinforcing portion (43).

In the above mentioned embodiments, the defects in the reinforcing portion were formed in such a manner that the cylindrical coil (11) and the plurality of rings (15) are arranged with the spacing (13) or (16) between every adjacent wires or rings to avoid contact of one with the other in the cylindrical partition structure (8), that the plurality of rings (24) are concentrically arranged with the spacing (25) between every adjacent rings to avoid contact of one with the other in the disc-like partition structure (21), and that the individual bar-like reinforcing pieces (47) in the first reinforcing portion (44) are arranged with the spacing (48) between every adjacent pieces to avoid contact of one with theother, the cylindrical coil (51) or the plurality of rings (55) in the second reinforcing portion (46) are arranged with the spacing (52) or (56) between every adjacent wires or rings to avoid contact of one with the other, and theinsulating layer (45) is provided between the first and second reinforcing portions (44)(46) in the cup-like partition structure (39). However, even if the cylindrical coils (11)(51), the plural rings (15)(24)(55) and the individual bar-like reinforcing pieces (47) are arranged to be contact between every adjacent members without providing the spacings (13)(52)(16)(25)(56)(48), or even if first and second reinforcing portion (44)(46) are contacted with each other without providing the insulating layer (45) therebetween, the resultant contact resistance allows in most cases to form defects for an eddy-current in the reinforcing portions (8)(21)(39).

Hereinafter there will be described embodiments in which the defects are formed in the reinforcing portion with such contact resistance.

Fig.13 shows an embodiment wherein the insulating layer (45) between the first and second reinforcing portions (44)(46) is dispensed within the cup-like partition structure (39) for the magnetic coupling pump (31) as shown in Figs. 8 to 10. That is, the cup-like partition structure (39) is constructed as follows. The plurality of bar-like reinforcing pieces (47) made of non-magnetic steels are concentrically annularly arranged over the outer periphery of the cup-like sealing portion (42) made of a resin material parallel to one another in the axial direction with the spacing (48) between every adjacent pieces, thereby to form the first reinforcing portion (44), and then the cylindrical coil (51) made of a non-magnetic steel is wound directly, i.e., not through the insulating layer (45), over the outer periphery of the first reinforcing portion (44) with the spacing (52) between every adjacent wires to avoid contact of one with the other, thereby to form the second reinforcing portion (46).

According to this embodiment, although the firstand second reinforcing portions (44)(46) are contacted with each other, the resultant contact resistance is generally several hundreds to several thousands times the specific resistance of the non-magnetic steels which are used to constitute both reinforcing portions (44)(46), so that the electric resistance in the radial direction against an eddy-current becomes fairly large. In other words, the contacted part between the first and second reinforcing portions (44)(46) is formed as a defect in the reinforcing portion (39) because of its contact resistance, and defect rendering the contact resistance functions cooperatively with the defects effected by both the spacings (52) of the cylindrical coil (51) and the spacings (48) between the individual reinforcing pieces (47) to extremely restrain the occurrence of an eddy-current in the reinforcing portion (39), so that the resultant eddy-current loss can be very reduced as compared with that in the conventional cup-like partition structure using a non-magnetic steel solely or as a reinforcement for the resin material.

Alternatively, in the arrangement of Fig. 13, even ifthe cylindrical coil (51) forming the

second reinforcing portion (46) is closely wound without providing the spacing (52) between every adjacent wires to allow contact of one with the other, as shown in Fig. 14, or even if, though not shown, the individual bar-like reinforcing pieces (47) forming the first reinforcing portion (44) are arranged to be contact with one another without providing the spacing (48), the circumferential electric resistance against an eddy-current in the first reinforcing portion (44) becomes fairly high due to the contact resistance of the adjacent bar-like reinforcing pieces (47), i.e., at the defects and the axial electrical tance in the second reinforcing portion (46) becomes fairly high due to the contact resistance of the adjacent wires of the cylindrical coil (51), i.e., at the defects, so that the radial electric resistance against an eddy-current between both reinforcing portions (44)(46) becomes fairly high due to the contact resistance therebetween. In this case, in addition to the effect of reducing the eddy-current loss as much as that in the arrangement of Fig. 13, there can be also attained such advantages that, corresponding to the absence of the spacings (48)(52) in both reinforcing portions (44)(46), the thermal, mechanical-strength of the cup-like partition structure (39) is, though to some degree, improved, the individual bar-like reinforcing pieces (47) can be arranged more easily in the fitst reinforcing portion (44), and the cylindrical coil (51) can be wound more easily in the second reinforcing portion (46).

Also in the embodiments of Figs. 13 and 14, the second reinforcing portion (46) may be composed of the plural rings (55), in place of the cylindrical coil (51), which are closely arranged with the adjacent end faces of the rings being contacted, as shown in Fig. 15 by way of an example. In case that the sufficient thermal, mechanical strength against the outer pressure is required, the sealing portion (42) may be resin-molded to enclose therein the reinforcing portion (43), also as shown in Fig. 15.

Fig. 16 shows an embodiment wherein, in the cylindrical partition structure (8) for the canned motor pump (1) shown in Fig. 2, the cylindrical coil (11) made of a non-magnetic steel is closely wound over the outer periphery of the cylindrical sealing portion (10) made of a resin material without providing the spacing (13) between the adjacent wires to allow contact of one with the other,thereby to form the reinforcing portion (12). As with the above mentioned embodiments, the axial electric resistance against an eddy-current in the reinforcing portion (12) of this embodiment becomes also fairly high due to the contact resistance at the part between the adjacent wires of the cylindrical coil (11), i.e., at the defect, so that the eddy-current loss will not be substantially caused.

Further, since the metal materials constituting the reinforcing portions (12)(26)(43) are contacted with each other between the adjacent members in this way so as to form the defects at thus contacted parts which have the fairly high electric resistance against an eddy-current, there can be likewise formed defects at the contacted parts between the sealing portions (10)(23)(42) and the reinforcing portions (12)(26)(43) which defects have the fairly high electric resistance against an eddy-current, even if the metal material continuous with no defect and having a constant thickness, which was used in the prior art partition structure, is now used for the sealing portions (10)(23)(42). In this case, although an eddy-current is caused in the sealing portions (10)(23)(42) in proportion to a thickness t of the metal material as represented by the aforesaid equation (1), the amount of eddy-current loss caused in the reinforcing portions (12)(26)(43) remains unchanged substantially even with use of the metal material for the sealing portions (10)(23)(42), so that it can be ignored in practical use as compared with the eddy-current loss caused in the sealing portions (10)(23)(42).

Stated otherwise,materials of high electric resistance such as glass, ceramic, rubber, etc. in addition to the above mentioned resin material are suitable for the sealing portions (10)(23)(42) in point of restricting the resultant eddy-current loss. But, in case that the pump-handled fluid is at particularly high temperature and accompanies with the large temperature difference during a heat cycle as well as an abrupt temperature change, or in case that the metal material is rather suitable in point of corrosion resistance because the pump-handled fluid is of a solvent,even if the metal material continuous with no defect and having a constant thickness is used for the sealing portions (10)(23)(42) on the assumption that the thermal, mechanical strength will be borne by the metal-made reinforcing portions (12)(26)(43), which have a very small eddy-current loss, as previously stated according to the present invention, the eddy-current loss of the sealing portions (10)(23)(42) and hence the partition structures (8)(21)(39) can be reduced to a very small amount in proportion to a thickness t of the metal material as represented by the equation (1), because the metal material can have a very thinned thickness as compared with the conventional partition structure in which the metal material continuous with no defect and having a constant thickness was used solely or as a reinforcement for the resin material.

Figs. 18 and 18 show embodiments wherein the metal material is used for the sealing portion. More specifically, the cylindrical partition structure (8) of Fig. 17 is so constructed that the cylindrical coil (11) made of a metal material is directly closely wound over the inner periphery of the cylindrical sealing portion (10), which is made of a metal material continuous with no defect and having a constant thickness, in a contact relation therewith to form

reinforcing portion (12). On the other hand, the cup-like partition structure (39) of Fig. 18 is so constructed that the cylindrical coil (51) made of a metal material is directly closely wound over the outer periphery of the cup-like sealing portion (42), which is made of a metal material continuous with no defect and having a constant thickness, in a contact relation therewith to form the second reinforcing portion (46), and then the individual bar-like reinforcing pieces (47) made of metal materials are directly arranged over the outer periphery of the second reinforcing portion (46) in a contact relation therewith to form a first reinforcing portion (44).

It is to be noted that the first reinforcing portion (44) may be dispensed with as required in the cup-like partition structure (39) shown in Fig. 18.

Although, in the respective embodiments as stated above, the reinforcing portions (12)(26)(43) were provided with spacings (13)(16)(25)(48)(52)(56) between every adjacent members to form the defects, or all of the adjacent members are contacted with each other to form the defects, the defects in the reinforcing portions (12)(26)(43) are not limited to those of such arrangements and may be modified so long as they can render the high electric resistance against an eddy-current.

For example, in a magnetic coupling pump incorporating an axial air-gap type magnetic coupling as shown in Fig. 19, the disc-like sealing portion (23) formed of a resin material may enclose therein a reinforcing portion (61), which is made of a metal material and formed into a lattice shape to provide the defects, thereby to construct the disc-like partition structure (21), as seen from Figs. 20 and 21. In the magnetic coupling pump (31) incorporating the radial air-gap type magnetic coupling (33) as shown in Fig. 8, a cup-like reinforcing portion (63) made of a metal material and provided with a number of small holes as defects at least in the region locating in the magnetic air-gap (38) may be coated over the outer periphery and the outer side face of the cup-like sealing portion (42) made of a resin material, therebyto construct the cup-like partition structure (39), as seen from Fig. 22. It is, however, to be noted that effect of reducing the eddy-current loss is lowered to not small eztent.

Moreover, although, in the respective embodiments as mentioned above, the partition structures (8)(21)(39) are constructed by contacting the reinforcing portions (12)(26)(43)(61)(63) with the sealing portions (10)(23)(42), the cylindrical partition structure may be so constructed, as shown in Fig. 23 by way of an example, that a cylindrical metal material continuous with no defect and having a constant thickness is formed on the outer periphery thereof with a spiral groove (64), a number of circumferential grooves or the like,the groove (64) or others serving as defect(s) in the reinforcing portion, so as to construct a partition structure which comprises the one-piece metal material with the radially outer side relative to the bottom of the groove (64) being as the reinforcing portion (12) and the radially inner side being as the sealing portion (10). Also in this case, however, the effect of reducing the eddy-current loss can not be anticipated to become so much as that in the parttition structure (8) shown in Fig. 17.

In addition, combinations of the sealing portion and the reinforcing portion are also not limited to those in the above mentioned respective embodiments. For example,as with the cylindrical partition structure (8) shown in Fig. 24, plural pairs of sealing portions (10) and the reinforcing portions (12) may be combined to construct a partition structure desirously modified in accordance with particular application.

While the present invention has been described with reference to embodiments in which the invention is applied to pumps, it is similarly applicable to other glandless fluid machines adopting a canned motor or magnetic coupling, suchas blower, compresor,stirrer,etc. It should be also understood that, in addition to a synchronous type magnetic coupling using a magnet mounted on the driven side rotor as shown in above mentioned embodiment, the present invention can be of course applied to other various types of magnetic couplings such as a hysteresis type magnetic coupling using a magnetic hysteresis material for the driven side rotor, an eddy-current type magnetic coupling using a metal material of high conductivity such as copper or aluminium for the driven side rotor or using a cage rotor, a magnetic coupling using a DC-excited magnetic pole for the drive side magnet.

CLAIMS

1. In a partition structure which is disposed in the revolving magnetic field of a canned motor, magnetic coupling,etc. to be used in a fluid machine for interrupting between the inner and outer sides of a fluid system, the partition structure for said fluid machine comprising a sealing portion adapted to prevent leakage of a fluid and a reinforcing portion made of a metal material for increasing the thermal, mechanical strength, said reinforcing portion having defects against aneddy-current which cross lines of magnetic force of said revolving magnetic field at a right angle and which provide electric disconnections on the cylindrical or planar surface defining said reinforcing portion, so that the occurrence of an eddy-current resulted from said revolving magnetic field is restricted.

2. A partition structure for a fluid machine according to claim 1, wherein said reinforcing

portion is so constructed that a cylindrical coil made of a metal material or a plurality of rings made of a metal material and arranged side by side in the axial direction are disposed over the outer or inner periphery of said cylindrical sealing portion in a close contact relation therewith.

3. A partition structure for a fluid machine according to claim 2, wherein said cylindrical coil or said plurality of rings are contacted between every adjacent wires or rings to form said reinforcing portion.

4. A partition structure for a fluid machine according to claim 2, wherein at least said sealing portion, or reinforcing portion, or both are provided in the plural number.

5. A partition structure for a fluid machine suitwable for use in a magnetic coupling,said partition structure comprising: a cup-like sealing portion adapted to prevent leakage of a fluid; a first reinforcing portion for increasing the thermal, mechanical strength of said sealing portion in the axial direction; and a second reinforcing portion for increasing the thermal, mechanical strength of said sealing portion in the radial direction, wherein said first reinforcing portion is so constructed that a plurality of bar-like reinforcing pieces made of a metal material are concentrically annularly arranged over a cylindrical part of said cup-like sealing portion substantially parallel to one another in the axial direction, and said second reinforcing portion is so constructed that a cylindrical coil made of a metal material or a plurality of rings made of metal materials and arranged side by side in the axial direction are concentrically disposed over the cylindrical part of said cup-like sealing portion.

6. A partition structure for a fluid machine according to claim 5 suitable for use in a magnetic coupling,wherein said cylindrical coil or said plurality of rings arranged side by side in the axial direction are contacted between every adjacent wires or rings to form said second reinforcing portion.

7. A partition structure for a fluid machine according to claim 5 suitable for use in a magnetic coupling,wherein said plurality of bar-like reinforcing pieces are contacted between every adjacent pieces.

8. A partition structure for a fluid machine according to claim 6 suitable for use in a magnetic coupling, wherein said plurality of bar-like reinforcing pieces are contacted between every adjacent pieces.

9. A partition structure for a fluid machine according to claim 5 suitable for use in a magnetic coupling, wherein said first and second reinforcing portions are contacted with each other through an insulating layer adapted to increase the electric resistance in the radial direction against an eddy-current caused between said both reinforcing portions.

10. A partition structure forafluid machine,substantially as hereinbefore described with reference to the accompanying drawings.

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